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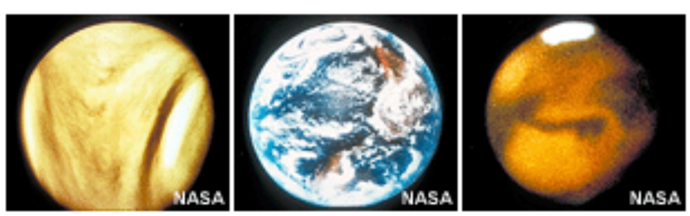
The Greenhouse Effect

This document provides an overview of the earth's atmospheric "greenhouse effect" by briefly exploring the atmospheres of nearby planets and discussing our atmosphere's greenhouse gases. The general concepts found in this section include the following:

- The earth's "greenhouse effect" is what makes this planet suitable for life as we know it.
- The earth's atmosphere contains trace gases, some of which absorb heat. These gases (water vapor, carbon dioxide, methane, ozone, and nitrous oxide) are referred to as "greenhouse gases."
- Albedo has an important influence on the earth's temperature.
- Greenhouses are structures designed to retain heat.
- The heat-trapping ability of a greenhouse is influenced by a number of factors including the transparency of the greenhouse cover, color of the surfaces inside the greenhouse, and type of surfaces inside.

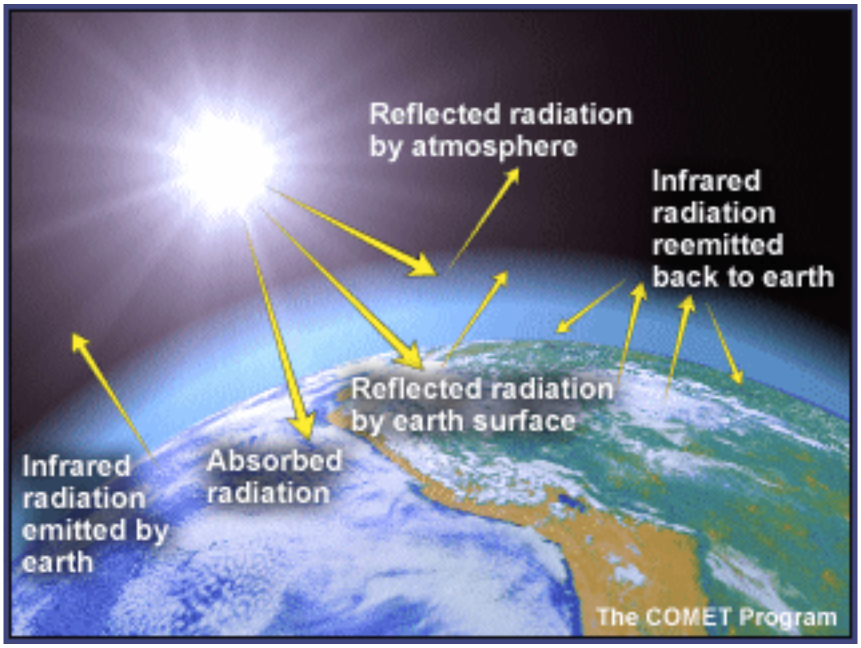
Introduction

The Goldilocks Principle can be summed up neatly as "Venus is too hot, Mars is too cold, and Earth is just right." The fact that Earth has an average surface temperature comfortably between the boiling point and freezing point of water, and thus is suitable for our sort of life, cannot be explained by simply suggesting that our planet orbits at just the right distance from the sun to absorb just the right amount of solar radiation. Our moderate temperatures are also the result of having just the right kind of atmosphere. A Venus-type atmosphere would produce hellish, Venus-like conditions on our planet; a Mars atmosphere would leave us shivering in a Martian-type deep freeze.



	Venus	Earth	Mars
Surface temperature	450°C	13°C	-53°C

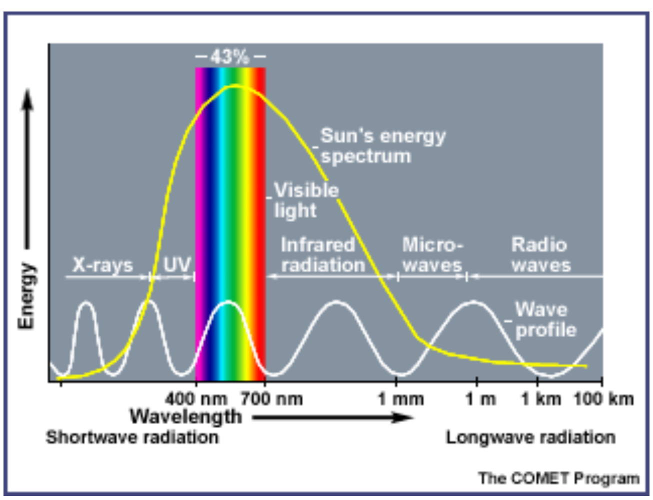
Instead, parts of our atmosphere act as an insulating blanket of just the right thickness, trapping sufficient solar energy to keep the global average temperature in a pleasant range. The Martian blanket is too thin, and the Venusian blanket is way too thick! The 'blanket' here is a collection of atmospheric gases called 'greenhouse gases' based on the idea that the gases also 'trap' heat like the glass walls of a greenhouse do.



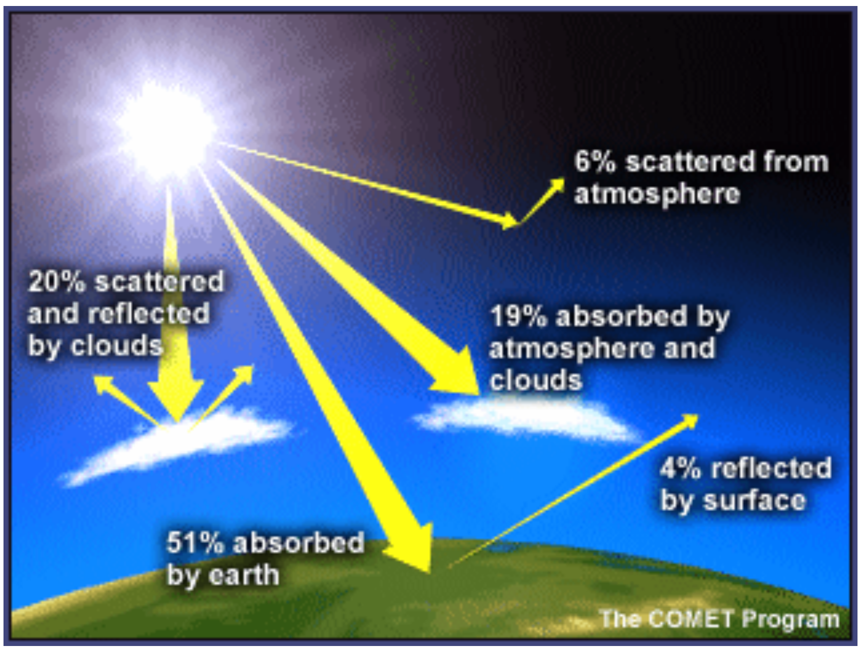
These gases, mainly water vapor, carbon dioxide, methane, and nitrous oxide, all act as effective global insulators. To understand why, it's important to understand a few basic facts about solar radiation and the structure of atmospheric gases.

Solar Radiation

The sun radiates vast quantities of energy into space, across a wide spectrum of wavelengths.



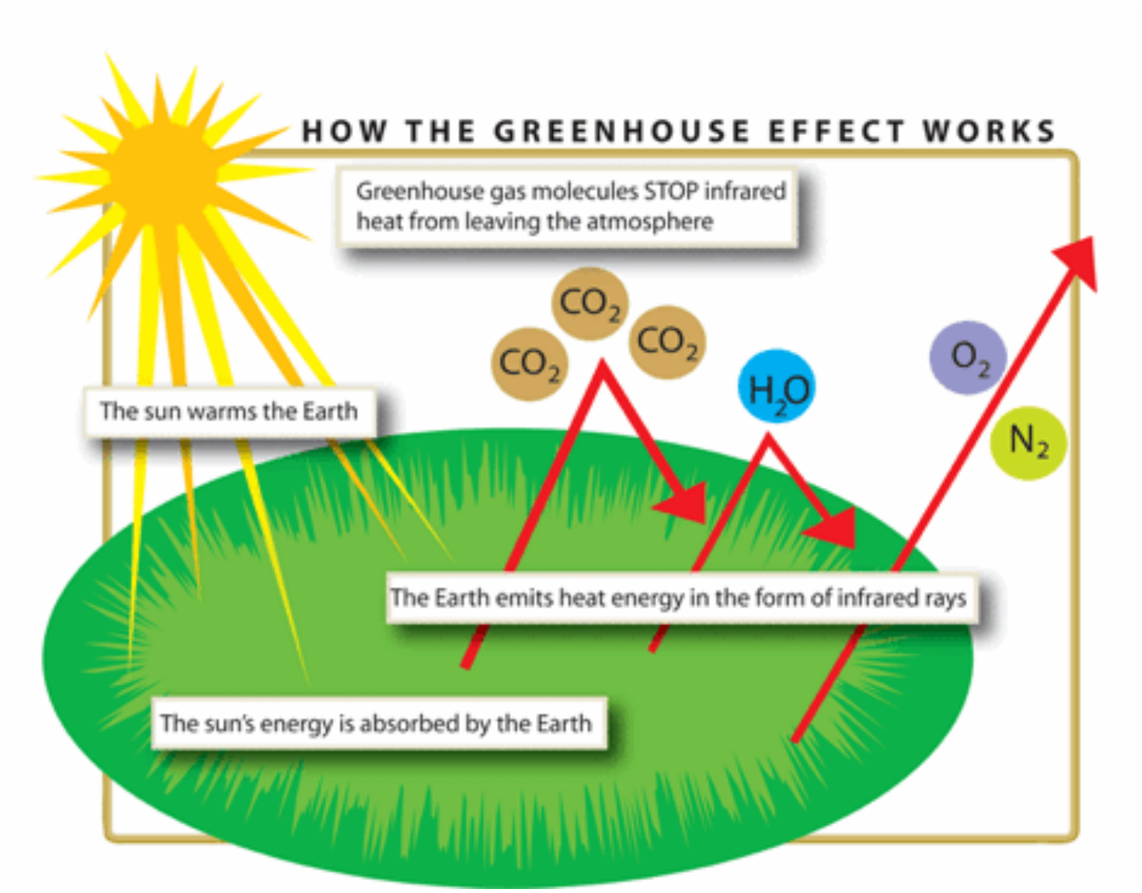
Most of the radiant energy from the sun is concentrated in the visible and near-visible parts of the spectrum. The narrow band of visible light, between 400 and 700 nm, represents 43% of the total radiant energy emitted. Wavelengths shorter than the visible account for 7 to 8% of the total, but are extremely important because of their high energy per photon. The shorter the wavelength of light, the more energy it contains. Thus, ultraviolet light is very energetic (capable of breaking apart stable biological molecules and causing sunburn and skin cancers). The remaining 49 - 50% of the radiant energy is spread over the wavelengths longer than those of visible light. These lie in the near infrared range from 700 to 1000 nm; the thermal infrared, between 5 and 20 microns; and the far infrared regions. Various components of earth's atmosphere absorb ultraviolet and infrared solar radiation before it penetrates to the surface, but the atmosphere is quite transparent to visible light.



Absorbed by land, oceans, and vegetation at the surface, the visible light is transformed into heat and re-radiates in the form of invisible infrared radiation. If that was all there was to the story, then during the day earth would heat up, but at night, all the accumulated energy would radiate back into space and the planet's surface temperature would fall far below zero very rapidly. The reason this doesn't happen is that earth's atmosphere contains molecules that absorb the heat and re-radiate the heat in all directions. This reduces the heat radiated out to space. Called 'greenhouse gases' because they serve to hold heat in like the glass walls of a greenhouse, these molecules are responsible for the fact that the earth enjoys temperatures suitable for our active and complex biosphere.

Greenhouse Gases

Carbon dioxide is one of the greenhouse gases. It consists of one carbon atom with an oxygen atom bonded to each side. When its atoms are bonded tightly together, the carbon dioxide molecule can absorb infrared radiation and the molecule starts to vibrate. Eventually, the vibrating molecule will emit the radiation again, and it will likely be absorbed by yet another greenhouse gas molecule. This absorption-emission-absorption cycle serves to keep the heat near the surface, effectively insulating the surface from the cold of space.



Carbon dioxide, water vapor, methane, nitrous oxide, and a few other gases are greenhouse gases. They all are molecules composed of more than two component atoms, bound loosely enough together to be able to vibrate with the absorption of heat. The major components of the atmosphere (nitrogen, N_2, and oxygen, O_2) are two-atom molecules too tightly bound together to vibrate and thus they do not absorb heat and contribute to the greenhouse effect.

Greenhouse Effect

Atmospheric scientists first used the term 'greenhouse effect' in the early 1800s. At that time, it was used to describe the naturally occurring functions of trace gases in the atmosphere and did not have any negative connotations. It was not until the mid-1950s that the term greenhouse effect was coupled with concern over climate change. And in recent decades, we often hear about the greenhouse effect in somewhat negative terms. The negative concerns are related to the possible impacts of an **enhanced** greenhouse effect. This is covered in more detail in the Global Climate Change section of this Web site. It is important to remember that without the greenhouse effect, life on Earth as we know it would not be possible.

While the earth's temperature is dependent upon the greenhouse-like action of the atmosphere, the amount of heating and cooling are strongly influenced by several factors just as greenhouses are affected by various factors.

In the atmospheric greenhouse effect, the type of surface that sunlight first encounters is the most important factor. Forests, grasslands, ocean surfaces, ice caps, deserts, and cities all absorb, reflect, and radiate radiation differently. Sunlight falling on a white glacier surface strongly reflects back into space, resulting in minimal heating of the surface and lower atmosphere. Sunlight falling on a dark desert soil is strongly absorbed, on the other hand, and contributes to significant heating of the surface and lower atmosphere. Cloud cover also affects greenhouse warming by both reducing the amount of solar radiation reaching the earth's surface and by reducing the amount of radiation energy emitted into space.

Scientists use the term **albedo** to define the percentage of solar energy reflected back by a surface. Understanding local, regional, and global albedo effects is critical to predicting global climate change.

Concluding Thoughts

The ability of certain trace gases to be relatively transparent to incoming visible light from the sun, yet opaque to the energy radiated from the earth is one of the best understood processes in the atmospheric sciences. This phenomenon, the greenhouse effect, is what makes the earth habitable for life.

1- On a new Vocabulary Tracker sheet, please record the new Global Learning Target, LT2.

2- On that new Vocab Tracker, record and define the following terms using this packet:
Greenhouse Effect
Greenhouse Gas
Albedo

3- On a separate sheet of notebook paper, please answer the following questions.

1. What is a greenhouse and how does it work?
2. How is the earth's atmosphere similar to a greenhouse?
3. What factors influence the function of a greenhouse?
4. What is albedo and how is it related to understanding global climate change?
5. What are the limitations in comparing the earth's atmosphere to a greenhouse?